Claims

What is claimed is:

1. A method for tracking eye gaze, comprising the steps of:

focusing a single camera on an eye of subject viewing a gaze point on a screen while directing light toward the eye;

sampling eye gaze data pertaining to a glint and pupil image of the eye in an image plane of the single camera;

determining eye gaze parameters from the eye gaze data, wherein the eye gaze parameters include: Δx, Δy, r, θ, g_x, and g_y, wherein Δx and Δy are orthogonal projections of a pupil-glint displacement vector directed from the center of the pupil image to the center of the glint in the image plane, wherein r is a ratio of a major semi-axis dimension to a minor semi-axis dimension of an ellipse that is fitted to the pupil image in the image plane, wherein θ is an angular orientation of the major semi-axis dimension in the image plane, and wherein g_x, and g_y are mutually orthogonal coordinates of the center of the glint in the image plane; and

estimating the gaze point from the eye gaze parameters.

2. The method of claim 1, wherein the gaze point is characterized by orthogonal coordinates X_{SG} and Y_{SG} in the coordinate system of the screen, and wherein the estimating step comprises estimating X_{SG} and Y_{SG} independently.

3. The method of claim 2, wherein estimating X_{SG} utilizes a first mapping function based on a generalized regression neural network architecture, and wherein estimating Y_{SG} utilizes a second mapping function based on the generalized regression neural network architecture.

4. The method of claim 3, wherein the first mapping function utilizes a first probability density function having a first Gaussian kernel characterized by a first width σ_1, and wherein the second mapping function utilizes a second probability density function having a second Gaussian kernel characterized by a second width σ_2.

5. The method of claim 4, wherein $\sigma_1 = \sigma_2$.

6. The method of claim 4, wherein $\sigma_1 \neq \sigma_2$.

7. The method of claim 3, wherein the first mapping function is calibrated with n calibration data samples, wherein the second mapping function is calibrated with the n data samples, and wherein n is at least 2.

8. The method of claim 7, wherein the generalized regression neural network architecture of the first and second mapping functions includes an input layer having 6 nodes, a hidden layer coupled to the input layer and having n nodes, a summation layer coupled to the hidden layer and having 2 nodes, and an output layer coupled to the summation layer and having 1 node.

9. The method of claim 7, wherein the method further comprises the steps of:

partitioning the screen into a two-dimensional array of screen areas; and

classifying a vector of the eye gaze parameters into a screen area of the screen areas.

10. The method of claim 7, wherein the classifying step comprises:

classifying the vector of the eye gaze parameters into a first screen area of the screen areas, using a whole classifier;

determining nearest neighbor screen areas of the first screen area; and

reclassifying the vector of the eye gaze parameters into the screen area, using a sub-classifier pertaining to the nearest neighbor screen areas.

11. The method of claim 10, wherein the method further comprises assigning the estimated gaze point to a region of the screen that has an area of about 1/8 of the area of the screen, wherein said assigning has an average accuracy of at least about 95% even if any of the following head motions of the subject occur during the focusing step: up to 6 inches of left/right head translation, up to 6 inches of up/down head translation movement, up to ±20 degrees of left/right head rotation, and up to ±15 degrees of up/down head rotation.

12. The method of claim 7, wherein the method further comprises assigning the estimated gaze point to a region of the screen that has an area of about 1/8 of the area of the screen, wherein said assigning has an average accuracy of at least about 85% even if any of the following head motions of the subject occur during the focusing step: up to 6 inches of left/right head

translation, up to 6 inches of up/down head translation movement, up to ±20 degrees of left/right head rotation, and up to ±15 degrees of up/down head rotation.

13. The method of claim 1, wherein no camera other than the single camera is focused on the eye during the focusing step.

14. A computer system comprising a processor and a computer readable memory unit coupled to the processor, said memory unit containing instructions that when executed by the processor implement a method for tracking eye gaze, said method comprising the computer implemented steps of:

processing eye gaze data pertaining to a glint and pupil image of an eye in an image plane of a single camera, wherein the eye is comprised by a subject, and wherein the single camera is focused on the eye while the eye is viewing a gaze point on a screen and while light is directed toward the eye;

determining eye gaze parameters from the eye gaze data, wherein the eye gaze parameters include: Δx, Δy, r, θ, g_x, and g_y, wherein Δx and Δy are orthogonal projections of a pupil-glint displacement vector directed from the center of the pupil image to the center of the glint in the image plane, wherein r is a ratio of a major semi-axis dimension to a minor semi-axis dimension of an ellipse that is fitted to the pupil image in the image plane, wherein θ is an angular orientation of the major semi-axis dimension in the image plane, and wherein g_x, and g_y are mutually orthogonal coordinates of the center of the glint in the image plane; and

estimating the gaze point from the eye gaze parameters.

15. The computer system of claim 14, wherein the gaze point is characterized by orthogonal coordinates X_{SG} and Y_{SG} in the coordinate system of the screen, and wherein the estimating step comprises estimating X_{SG} and Y_{SG} independently.

16. The computer system of claim 15, wherein estimating X_{SG} utilizes a first mapping function based on a generalized regression neural network architecture, and wherein estimating Y_{SG} utilizes a second mapping function based on the generalized regression neural network architecture.

17. The computer system of claim 16, wherein the first mapping function utilizes a first probability density function having a first Gaussian kernel characterized by a first width σ_1, and wherein the second mapping function utilizes a second probability density function having a second Gaussian kernel characterized by a second width σ_2.

18. The computer system of claim 17, wherein $\sigma_1 = \sigma_2$.

19. The computer system of claim 17, wherein $\sigma_1 \neq \sigma_2$.

20. The computer system of claim 16, wherein the first mapping function is calibrated with n calibration data samples, wherein the second mapping function is calibrated with the n data samples, and wherein n is at least 2.

21. The computer system of claim 20, wherein the generalized regression neural network architecture of the first and second mapping functions includes an input layer having 6 nodes, a hidden layer coupled to the input layer and having n nodes, a summation layer coupled to the

hidden layer and having 2 nodes, and an output layer coupled to the summation layer and having 1 node.

22. The computer system of claim 20, wherein the method further comprises the steps of:

partitioning the screen into a two-dimensional array of screen areas; and

classifying a vector of the eye gaze parameters into a screen area of the screen areas.

23. The computer system of claim 20, wherein the classifying step comprises:

classifying the vector of the eye gaze parameters into a first screen area of the screen areas, using a whole classifier;

determining nearest neighbor screen areas of the first screen area; and

reclassifying the vector of the eye gaze parameters into the screen area, using a sub-classifier pertaining to the nearest neighbor screen areas.

24. The computer system of claim 23, wherein the method further comprises assigning the estimated gaze point to a region of the screen that has an area of about 1/8 of the area of the screen, wherein said assigning has average accuracy of at least about 95% even if any of the following head motions of the subject occur during the focusing step: up to 6 inches of left/right head translation, up to 6 inches of up/down head translation movement, up to ±20 degrees of left/right head rotation, and up to ±15 degrees of up/down head rotation.

25. The computer system of claim 20, wherein the method further comprises assigning the estimated gaze point to a region of the screen that has an area of about 1/8 of the area of the screen, wherein said assigning has average accuracy of at least about 85% even if any of the following head motions of the subject occur during the focusing step: up to 6 inches of left/right head translation, up to 6 inches of up/down head translation movement, up to ±20 degrees of left/right head rotation, and up to ±15 degrees of up/down head rotation.

26. The computer system of claim 14, wherein no camera other than the single camera is focused on the eye during the focusing step.